NASA TECHNICAL TRANSLATION NASA TT F-15,120

THE STRATEGY OF SPACE RESEARCH

H. Alfven

(NASA-TT-F-15120) THE STRATEGY OF SPACE RESEARCH (Kanner (Leo) Associates) 21 p HC $3.00 CSCL 22A
N73-31745
Unclas
G3/30 14607

Translation of "Strategiya kosmicheskikh issledovaniy," Priroda, No. 7, July 1972, pp. 11-14

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 SEPTEMBER 1973

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,120	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle THE STRATEGY OF SPACE RESEARCH		5. Report Date September 1973
		6. Performing Organization Code
7. Author(s) H. Alfven		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Leo Kanner Associates, P.O. Box 5187 Redwood City, California 94063		11. Contract or Grant No. NASw-2481
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Strategiya kosmicheskikh issledovaniy," Priroda, No. 7, July 1972, pp. 11-14.

16. Abstract

H. Alfven points out the inadequacy of chemical-fuel rocket engines and the need for new energy sources; in particular, he suggests the tapping of the cosmic plasma and the extracting of energy from the solar wind. Alfven stresses the social value of space research and the importance of space flights in any attempt to solve the cosmological problem. Flights to the asteroids and comets will be just as important as flights to the planets.

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	10	

THE STRATEGY OF SPACE RESEARCH

H. Alfven

Hannes Alfven is a Swedish physicist who occupies the Chair of Physics at the Stockholm Royal Technological Institute. He created a new branch of physics: cosmic electrodynamics, on the basis of which has been created a number of theories that elucidate many astrophysical phenomena. He is also occupied with the problem of the origin of cosmic rays and the problem of antimatter in the universe. He is a member of the Royal Academy of Sciences in Stockholm, a foreign member of the Academy of Sciences of the USSR and a member of a number of other academies and scientific societies. He is an active participant in the Paguoshskiy movement of scholars for disarmament and the relaxation of international tension. He is a Nobel prize laureate. In 1971 he received the highest award of the Academy of Sciences of the USSR: the M.V. Lomonosov gold medal. /11*

Dear colleagues and comrades! I wish to express my profound gratitude to the Academy of Sciences of the USSR for the great honor shown me: conferment of the Lomonosov medal for 1971. It is an especial pleasure to receive this award together with my old friend Academecian Ambartsumyan.

The name of Lomonosov reminded me of the celebration of his anniversary in the Soviet Union 10 years ago, when I represented the Swedish Academy of Sciences and in its name rendered due homage to the great scientist. On that occasion I had the opportunity to learn more about that remarkable man.

*Numbers in the margin indicate pagination in the foreign text.

Of Lomonosov's rich legacy, one treatise I consider to be of particular interest: "On the Origin of Arctic Ocean Icebergs." This treatise was published in 1763 in the "Transactions of the Royal Swedish Academy of Sciences" as a sign of Lomonosov's gratitude to the Academy, which had elected him as a member. In this treatise he propounds various theories and draws the conclusion that icebergs are formed not as the result of the freezing of sea water, as some thought, but arise from glaciers -- a conclusion that has turned out to be quite correct.

In Lomonosov's time arctic investigations were a daring attempt to explore geographical regions previously inaccessible to man. At the present time no such regions are left on earth, but man's striving to delve into the unknown remains as great as ever. The only difference -- and it is a big one -- is that in our time this unknown is located in cosmic space.

I am no historian, but I do think that it would be very interesting to trace how Lomonosov in his works, for example in the above-mentioned treatise, inspired subsequent generations of scholars to delve into unknown regions. Tsiolkovskiy, who founded the science of reactive motion, was probably one of Lomonosov's followers in this tradition, which led later to Korolev, to whom more than to anyone else belongs the merit of transforming the space age into a reality.

Let us recall some factors out of the history of space research. Its origins are bound up with the development of military rocketry, which arose during the Second World War, and later, with the development of control technique. Today these two forms of technology, together with atomic weapons, represent the most terrible threat for mankind in the event that peace should not be assured. Space research, too, has some military aspects. Nevertheless, the military significance of this research -- especially when it concerns more remote objects such as the moon and planets -- dwindles, while the significance of its purely scientific aspects looms larger. Collaboration between the astronauts of different countries will improve, the farther away they get from the earth.

In this connection it behooves us to dwell upon three aspects of space research.

Space Technology

In the technology of rocket motion, which has made space flights possible, to attain the necessary exhaust velocities /12 of combustion products, chemical reactions are employed. The discharge velocities of gases that can be secured by chemical fuel, however, amount to values of the order of one or a few kilometers per second, whereas for space flights velocities in excess of 10 km/sec are necessary. According to Tsiolkovskiy's formula, the velocity that a rocket can attain is the discharge velocity multiplied by the logarithm of the ratio of the launching mass of the rocket to the mass of the payload. This means that the launch weight turns out to be extremely great. Hence the conclusion that a chemical-fuel rocket is not very suitable for space flights. Future space flights will depend on the creation of new rocket engines. In other words, reaction motion under space conditions must be independent of that technology from which it once sprang.

New solutions in rocket-engine technology may be supplied by plasma physics. To accelerate a plasma to whatever velocity is necessary for space flight is relatively easy. Even though this new technology is practicable at the present time, it has not yet been utilized for space flights. This circumstance is due to two reasons. The first is the customary inertia inherent in all large-scale projects like space flights. The introduction of a new, revolutionary technology entails the organization of new research groups possessing knowledge in new fields, and this always requires time. The second reason is connected with the energy sources necessary for plasma ejection. As of today solar batteries can produce up to 10 kW. This is enough power for the new technology to assure the execution of many space tasks, but it is not enough for so abridging the duration of space flights as to place the entire solar system within reach.

At the present time a new technology utilizing nuclear energy is being worked out. This method, however, is difficult and, in a certain sense, dangerous. Therefore, other energy sources must be sought.

The cosmic plasma in the vicinity of the earth contains a great amount of energy that could be tapped. It is well known that in the magnetosphere there exist electric potential gradients of the order of several thousands of volts, and it is possible to work out methods of extracting this energy. The solar wind likewise contains large stores of energy that could be utilized. This ensues from the fact that the magnetosphere receives no less than 10^{12} W from the solar wind, which amounts to 0.1 MW per 1 m^2. We must look for ways of modeling these processes and drawing off energy from the solar wind. In principle, the energy extracted from the solar wind could impart to a spaceship a velocity of the same order as that of the solar wind itself. We could "sail under the pressure head of the solar wind." In the process the time required for space flights will be abridged by two orders of magnitude. But we are still far from this goal.

Man in Space

Technology cannot be a thing in itself. For society it is a negative factor, if it is employed for purposes of destruction. It serves as a positive factor only when it is employed for achieving useful goals. What is the use of space technology? One answer is obvious: study of the cosmic space surrounding us is just as important as was exploration of the polar regions in the time of Lomonosov and the rediscovery of America in the time of Columbus.

There has been much discussion about whether space research should be carried out with the aid of automatic vehicles controlled from the earth, or by way of launching man into space and landing him on the moon and other heavenly bodies. The two main space powers have chosen both of these ways, emphasizing now one, now the other of them.

Automatic flights are no less important than manned flights. The automatic flight method has undergone considerable development. It is sometimes said that the automatic vehicle can replace the astronaut and then there will no longer be any need to think about the necessity of safeguarding the life of people in space. At the same time, with the development of space flight technology and space medicine, the extreme efforts now necessary for sending man into space will become relatively slight. And, of course, man is far superior to automatic vehicles in carrying out observations.

If the sole purpose of space flights were scientific observations, then, in my opinion, it would be difficult to choose between manned and unmanned technology. Yet space activity has a multitude of other aspects. Its fundamental purpose must necessarily be to acquaint people with all the new possibilities that are being opened up in cosmic space. Sooner or later man will adapt to space to such an extent that he will be able to remain there for very long periods of time, perhaps even establish small colonies in space or on the surface of the heavenly bodies. The life that arose on earth is now beginning to spread beyond its confines. When man feels at home in space, he will make new discoveries there. He will not only observe, however, but also experiment. He will invent new technological methods and look upon the universe and himself with new eyes. For the common man no less than for the scientist this must be the most important problem of the space age.

Space Science

In the field of physics space research ushered in a new era. At the turn of the century spectroscopy discovered atomic physics. Thirty years later the cyclotron created nuclear physics. Another 30 years later Sputnik marked the emergence of a new field of science: space research. It now seems that this field will be the most active part of physics for the /13
remaining third of our century. The center of emphasis in science is constantly being shifted, but there are always groups of scientists who think that the most active scientific trend of their youth will always remain such.

In its first decade space research concentrated mainly on study of near space. It came to light that this is no mere emptiness and no structureless region, as it was thought earlier, but that it is filled with a plasma with different physical properties, permeated by electric currents and magnetic fields constituting a complex system. The knowledge acquired became the basis for a general understanding of the cosmic plasma. This, in turn, will be important for study of the structure of the galaxy and metagalaxy, as well as for solution of the cosmological problem as a whole, because new knowledge in the field of cosmic electrodynamics will make it possible for us to approach these problems from a less speculative position than at present. We have not yet gotten a thorough understanding of what radical changes in existing views of certain galactic phenomena this will lead to.

The second decade of space research has a different character. Insofar as some fundamental problems of the magnetosphere and interplanetary space still remain unsolved, it is safe to say that they will continue to attract a lot of attention. Nevertheless, the landing of people on the moon and space flights to Venus and Mars gave us such a wealth of new scientific data that the center of emphasis of space research began to be shifted toward intensive study of the moon and planets.

Up to the present this has borne a resemblance to the study of the polar regions and other inaccessible regions of the earth: detailed mapping was carried out in conjunction with geological, seismological, magnetic and gravitational surveys, as well as the study of atmospheric conditions. However, in studying the moon and planets, scientists were inevitably confronted with another problem, namely, elucidation of the origin of these heavenly bodies. Many recent scientific studies in the field of space research ended in hypotheses about the genesis and evolution of the solar system. It appears that this will remain one of the fundamental problems and, perhaps, the central problem, on which space science will be concentrated in the near future.

Origin of the Solar System

Astrophysics is in the main the application to cosmic phenomena of natural laws discovered in the laboratory. It follows from this that no partial domain of astrophysics will be ripe for a scientific method of approach until laboratory physics has achieved a certain level of development. For example, until the emergence of nuclear physics all attempts to understand how the stars produce their energy could be nothing but speculation without importance or lasting value.

The origin of the solar system was the subject of a great number of very contradictory hypotheses. The reason for this lay in a lack of fundamental knowledge in several important areas of physics and chemistry, which hampered the singling out of the processes that are really important from the point of view of the genesis and evolution of the solar system.

In the past too much attention was devoted to the formation of the planets of the solar system. And, as a negative consequence of this, many theories about the origin of the solar system were connected with theories about the sun's early history. This is in many respects an unreliable basis insofar as the formation of the sun (and other stars) is an extremely contradictory problem. In view of the fact that the satellite systems of Jupiter, Saturn and Uranus are very similar to our planetary system and at least just as typical as our system, it is more expedient to direct efforts at working out a general theory of the formation of secondary bodies around a central body, regarding the formation of planetary systems as no more than a special case of applying the general theory.

As more or less acknowledged at the present time, the sequence of events leading to the formation of the solar system was such that the initial gas and, possibly, dust, the first necessarily being partially ionized, gathered in certain regions around a central body and condensed into small solid granules. Out of these granules, as a result of accretion, the so-called nuclei of the planets were formed, which then changed into larger bodies: planets (if the central body was the sun) and satellites (if the central body was a planet). Formerly the asteroids were often regarded as the debris of a broken-up planet. At the present time, however, ever more arguments are being advanced in favor of the view that they represent an intermediate stage in the formation of planets or, at least, a stage similar to it. Clarification of these two positions will serve as an important element in our understanding of the evolution of the solar system.

In an analogous way, viewpoints are changing as to the interrelationship between comets and meteoritic bodies. Formerly it was thought that meteoritic bodies are the decay products of comets. Nowadays opinions are being expressed that the reverse process also exists: comets may be formed as the result of accretion in meteor showers. It will be obvious that the knowledge necessary for understanding such processes will grow rapidly owing to successes in certain research areas.

Just what space flights are particularly valuable for the study of the origin of the solar system?

Recent measurements of particles and fields in the magnetosphere and interplanetary space have increased the extent of our knowledge about the cosmic plasma. And what is more, the impacts of meteor particles against spacecraft give us information about very small bodies in near space that is important for understanding out of what material our planets were once formed. Particularly promising is proving to be the study of impacts of meteor bodies /14
against the surface of the moon and Mars and its satellites. These and other recent investigations are automatically contributing to a build-up of the knowledge necessary for solution of the problem of the formation of the solar system. But although this is important, there exist a number of critical problems that can only be solved by single-minded investigations.

It is thought that the most important flights after landing on the moon will be to Venus, Mars and the other planets. This is not necessarily so. Flights to the asteroids and comets, as well as to the satellites of the planets, will be at least just as interesting and of just as much benefit from the scientific point of view. There is no reason to treat the smaller heavenly bodies with disdain. The point of view that exists at the present time, it seems, reflects that interest in a heavenly body in space is proportional to its size. Nevertheless, for understanding the evolution of the solar system small bodies are more important. Insofar as some asteroids are the closest neighbors to the earth-moon system and their gravitational fields are small, such flights will also be simpler from the technological point of view.

I have attempted to outline what research is important for elucidation of the early history of the solar system. By carrying out this research, we may hope in time to understand how the structure of our part of the universe turned out to be such that we can live in it.